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AIR FORCE AIRCRAFT STRUCTURAL INTEGRITY PROGRAM: AIRPLANE REQUIREMENTS

HAROLD M. WELLS, JR.

TROY T. KING

TECHNICAL REPORT ASD-TR-66-57

MAY 1970

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FOREWORD

Information on this subject was formerly published in ASD Technical Note 61-141, and was later updated by ASD Technical Report 66-57, dated January 1968. The latter document as prepared under ESP Nr 921H-97826 has been revised as part of the AFSC Technical Report Program in accordance with AFSCR 80-20 and AFSCR 80-20/ASD Supplement 1. Additional revisions to this report will be made periodically to reflect any changes in requirements which may occur. The manuscript was released in August 1969 for publication as an ASD technical report.

Personnel of the Aeronautical Systems Division, the Air Force Laboratories, and the Air Force Logistics Command at W-PAFB contributed to the compilation of this report. There were also numerous contributions from industrial advisors of the ASD Aircraft Structural Integrity Program/Industry Advisory Group.

This Technical Report has been reviewed and is approved.

LEE V. GOSSICK, Major General, USAF
Commander, Aeronautical Systems Division
Air Force Systems Command

ABSTRACT

This report summarizes requirements for the airplane portion of the Aircraft Integrity Program based upon the results of experience and events since the inception of the program in 1958. It supplements the detailed structural specifications for Air Force airplanes and updates Aeronautical Systems Division Technical Report 66-57, dated January 1968. Applicable military specifications are referenced throughout.

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SECTION 1.0

INTRODUCTION

1.1 PURPOSE OF THE PROGRAM

Reliable, maintainable, on-line airplane systems are a mandatory requirement of any Air Force. One major item of an airplane system is the airframe structure with the attendant mandatory requirement of structural integrity. The Airplane Structural Integrity Program (ASIP) is a systematic procedure applied to a particular airplane system to enhance design, diagnose potential or impending failure, provide a basis for corrective action, and predict operational life expectancy of the airframe.

1.2 PROGRAM OBJECTIVES

Specific objectives of the Airplane Structural Integrity Program are to:

(1) Establish, evaluate, and substantiate structural integrity (airframe strength and service life) of airplane systems.

(2) Continually re-evaluate the structural integrity program by utilizing inputs from operational usage.

(3) Develop statistical techniques for the evaluation of operational usage and for logistic support (maintenance, inspection, supplies).

(4) Develop and incorporate improved structural criteria and methods of design, evaluation, and substantiation of airplane systems.

1.3 BACKGROUND

1.3.1 Initial Documentation by WCLS-TM-58-4

As a result of structural fatigue problems that developed on first-line USAF airplanes in the late 1950's, presentations were made by ARDC structures personnel from W-PAFB to principal Air Force Staff Members. These

presentations precipitated telegrams and letters which directed AMC, ARDC, and consequently WADD (AFLC, AFSC, and ASD) to take all necessary steps to ensure adequate service life of first-line airplanes. The Aircraft Laboratory issued Technical Memorandum WCLS-TM-58-4 on 27 June 1958 to "allow immediate implementation of this newly required fatigue evaluation." TM-58-4 was prepared "to present, in as detailed a manner as possible, the general requirements incident to this new fatigue certification program." Since this was the initial documentation, the requirements were "presented as a guide to establishing the required fatigue evaluation programs and are not necessarily hard and fast requirements in all instances." Hq USAF established specific requirements for service life in terms of flight hours and number of landings (Table I)*.

1.3.2 Formal Documentation

The Air Force structural integrity program was formally established by Hq USAF message AFCV C27229-M, dated 19 November 1958, and documented by "ARDC-AMC Program Requirements for the Structural Integrity Program for High Performance Aircraft," dated 16 February 1959. This document was prepared jointly by ARDC and AMC, and divided the work of the ASIP into eleven phases.

1.3.3 Documentation by ASD-TN-61-141 and ASD-TR-66-57

The program was subjected to extensive review in 1961 by engineering and weapons systems personnel of ASD. At this time the program requirements were expanded to address the entire structural integrity (strength and service life) effort, whereas the earlier documentation was concerned only

* Experience subsequent to 1959 has revealed that the specific aircraft types contained in Table I,do not cover all airplane systems being procured by the Air Force. Also, the specific numbers listed in the table are not inviolable. Therefore, Table I now merely represents a guide for establishing life requirements for new systems. In accordance with AFR 80-13, the estimated utilization data (including service life requirements) for future airplane systems will be provided by the Using Command and will be contained in the procurement specifications.

TABLE I

Service-Life Requirements *

Aircraft Type - Operational	Flight Hours	Nr of Landings
Bomber, Ground Alert	10,000	5,000
Air Alert	40,000	6,000
Air/Ground Alert	10,000	4,000
Tactical	5,000	2,500
Cargo, Assault	10,000	5,000
Medium and Heavy	30,000	12,000
Utility	15,000	10,000
AEW and C	50,000	10,000
Tanker	10,000	7,500
Fighter	4,000	4,000
Trainer	15,000	37,500

* This information was extracted from Hq USAF (AFODC) letter, "Aircraft Service Requirement," 5 October 1959.

with fatigue evaluation programs. This resulted in the publication of ASD Technical Note 61-141 (DDC document Nr AD-268-501) in September 1961. The phases into which the ASIP was subdivided were revised and work to date has been performed under the updated phases shown in that document, as follows: Phase I, Design Information; Phase II, Initial Design Analysis; Phase III, Testing; Phase IV, Final Structural Integrity Analysis; Phase V, Actual Operational Usage.

In January 1968, ASD-TR-66-57 (DDC document Nr AD-826-492) was published as part of the continuing effort to update the ASIP requirements. The revision provided updated procedures, definitions, and rationale for the program. The primary change was to require full-scale cyclic tests of two airframes in contrast to earlier requirements which specified one fatigue article. Another change was that parametric analyses were specified for airplane

systems to account for the variation in damage accumulation that occurs between individual aircraft.

1.4 USE OF THIS DOCUMENT

This report is intended for joint use by Industry and the Air Force. Its major purpose is to outline steps for achieving and requirements for ensuring structural integrity of Air Force airplanes. Section 2.0 of this report gives the discussion and requirements for each element of the ASIP. The majority of detailed requirements are published in existing military specifications and will only be referenced here, not repeated. Various program phases, which are not included elsewhere, are discussed at length and the requirements for these phases are contained herein. Thus, this report serves the dual role of presenting an overall program discussion and an index to pertinent specific requirements. The applicable specifications (and the latest revisions thereto) for a particular airplane system will be as specified in the applicable system procurement specifications.

The requirements in this report apply to airplanes as defined in the usual sense in the USAF dictionary (page 33, definition 2. a)* and as such are not strictly applicable to helicopters or similar VTOL vehicles. While the six major phases and some of the elements defined herein are applicable to other types of aircraft, a structural integrity program for aircraft types other than airplanes must be established on an individual basis at present. Formalized requirements for helicopters and similar VTOL aircraft structural integrity will be established in the future.

The basic requirement and associated responsibilities for Air Force aircraft structural integrity are contained in AFR 80-13.

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* An airplane is a power driven aircraft having a fixed wing or an adjustable fixed wing.

1.5 GENERAL CONSIDERATIONS AND TERMINOLOGY

1.5.1 Fatigue Certification Program

The area of establishment of structural integrity for static loads is generally well-known insofar as the program elements necessary and the scheduling of these elements. The orderly pattern of the elements (Figure 1) of establishing design criteria, performing loads analyses, performing element and component tests for design, performing the full-scale static test, and summing the entire analytical and test results into a final Strength Summary and Operating Restrictions Report is familiar to all.

The area of establishment of structural integrity for repeated loads is more complex because of the irregular feedback of operational data into the fatigue analyses and cyclic tests (Figure 2). For example, in the case of static stress, the analysis is presented as a final item prior to the conduct of the static test, whereas the fatigue analysis consists of several analyses because the actual operational data is not available during the initial design analysis phase. The fatigue analysis submitted prior to the start of cyclic test (paragraph 2.2.3) is an initial analysis and is preliminary in nature as it is based on planned operational usage. The analysis based on the results of the airframe fatigue test is the second phase (paragraph 2.4.2) in the fatigue analysis. Some actual operational usage data might be available, but full squadron operation is not normal at this stage. The "final" service-life analysis is the result of including the data from actual operational use. Consequently, this last analysis is never truly final because it must continually undergo revision when operational data dictate that a change is needed.

Figure 2 shows the extent and interrelationships of the various elements of analyses, test, and actual operational usage data that are required in the Air Force Fatigue Certification Program. The results of these elements are combined to provide a certified fatigue life for Air Force airplanes together with a basis for establishing structural modification schedules, life tradeoffs, future planning, and program evaluations and studies.

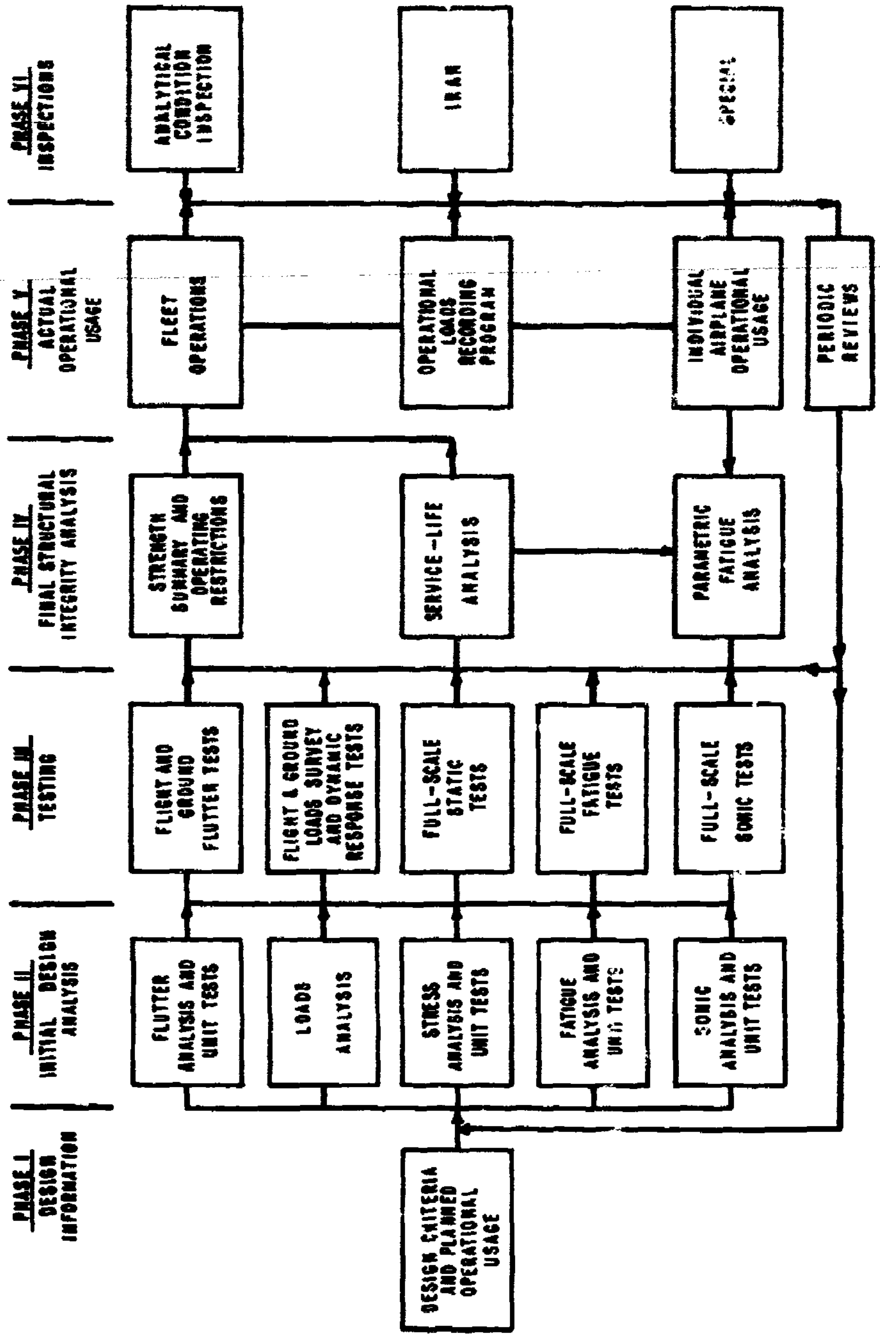

Figure 1. ASIP Flow Diagram

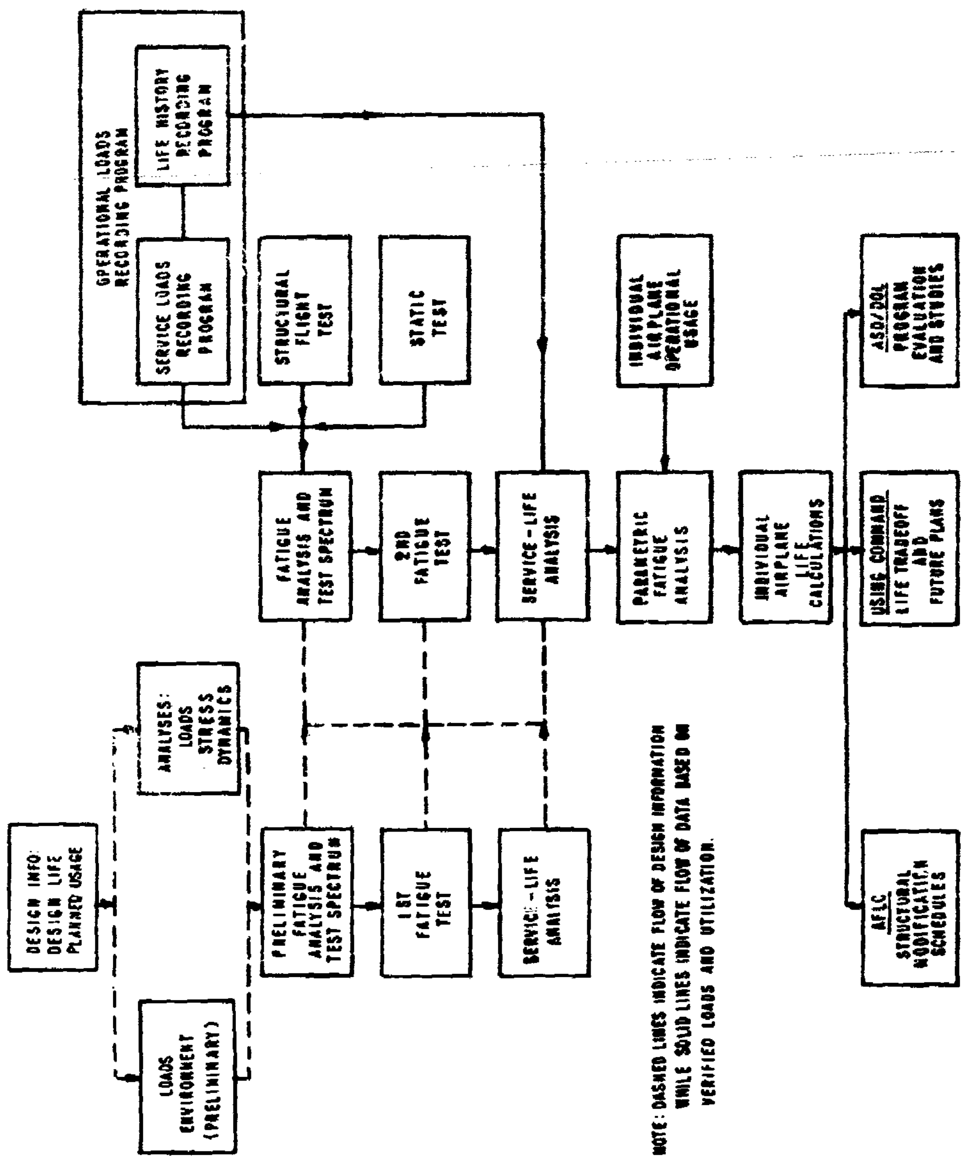

Figure 2. Fatigue Certification Program

For a new design, a Fatigue Certification Program can be clearly defined, but for an aircraft already in the inventory, the picture is not always clear. All of the documentation on this comprehensive and complex program has had to contend with the communications problem of dual definition of "new airplane" requirements and "existing airplane" requirements. For existing airplanes with no initial structural integrity program of the extent defined herein, specific requirements must be determined on an individual system basis.

1.5.2 Damage-Tolerant Considerations

The predominant theme used in defining fatigue requirements is based on the safe-life concept. This requires that all fatigue-critical areas be identified through cyclic fatigue tests. Suitable modifications as may be required to improve the fatigue resistance of these areas are incorporated prior to delivery or are programmed into the Modification and Maintenance Schedule for the airplane. This minimizes the nonscheduled inspection and maintenance requirements and ensures maximum availability of the airplane in service.

The term "damage tolerant", as applied to an airplane structure or member thereof, means that the structure remaining or a portion of the same structure can sustain a percentage of its design load without catastrophic failure or excessive structural deformation following the initiation of a fracture or crack. Analysis and tests must show that catastrophic failure or excessive structural deformation, which could adversely affect the flight characteristics of the airplane, will not occur after failure or obvious partial failure of a single principal structural element or load path.

The purpose of damage-tolerant design is to aid in preventing loss of life and airplane due to unusual environment, use, or damage and is not restricted only to fatigue considerations. The incorporation of damage-tolerant concepts is required, but considerable effort is required to arrive at definitions, design criteria, and test criteria mutually acceptable to the procuring activity and the contractor. The structural design of USAF airplanes should include damage-tolerant design criteria and evaluation where practical and consistent with

accepted design practices. The fact that a part can be inspected and repaired prior to catastrophic failure does not negate service-life or testing requirements.

The successful implementation of damage-tolerant design depends to a great extent on the effectiveness of the inspection, and the frequency of inspection in relation to the rate of growth of the damage with major consideration given to the containment of the damage and the severity of operational conditions. The effectiveness must be such that any damage capable of becoming catastrophic is found before it endangers the airplane. Therefore, both structural design and inspection techniques must be adequate to attain the required standards of inspection. The rate of damage growth in relation to the frequency of inspections should be slow enough that damage that has already started, but has failed to be detected at one inspection period, will not reduce the strength of the structure below the required minimum before the next inspection is conducted.

The size of fatigue cracks or cracks caused by other damage-inducing media and the comprehensive inspection periods and procedures are based on the premise that a crack should be limited in growth by positive "stoppers" or contained in extent of growth by geometrical or other configuration characteristics. Dependence should not be placed on slow rates of growth alone.

1.5.3 Scatter Factor

Another consideration which applies either to a safe-life or to a damage-tolerant design is the inherent scatter in fatigue life. This is accounted for by a scatter factor. It is appropriate that the term be defined prior to supplying specific data on the subject.

General Definition - Scatter factor is that value applied to the life (based on cyclic fatigue test results) to establish a safe life appropriate to a structure composed of required materials having a fatigue strength less than the average and subjected to a load history higher than the average. This factor (or series of factors) is derived from considerations of scatter in fatigue performance of

nominally identical structures tested under the same loading conditions, plus allowance for: manufacturing tolerances, number of specimens tested, and the effect of loads and environment not simulated in accelerated ground testing. The overall scatter factor comprises at least the following:

Loads Spectra Factor - That value derived for loading conditions based on consideration of the scatter in maneuver, gust, and ground loads within the family of a particular airplane series. The value may be modified when the actual loading conditions, as obtained from an instrumented airplane, are used to determine what life has been expended, or when a number of instrumented airplanes yield information on the variation of loading for that particular airplane model and operational assignment.

Test Scatter Factor - That value which is applied to the cyclic test conditions to account for the scatter in fatigue performance of nominally identical structures tested under the same loading conditions, plus allowance for normal manufacturing tolerances and number of test specimens.

It is also necessary to define a component scatter factor as that value which is applied to cyclic tests of structural components to account for the inability to fully simulate full-scale test setups, internal loads distributions, and boundary conditions.

The overall minimum values of the scatter factor to be used in fatigue evaluation are discussed in paragraphs 2.2.6.1.2.1 and 2.3.1.2.

SECTION 2.0

ASIP REQUIREMENTS BY PHASES

2.1 DESIGN INFORMATION (PHASE I)

The design information phase encompasses all efforts required to apply the existing theoretical, experimental, applied research, and operational experience to specific structural design criteria for the airplane system. The objective of this phase is to ensure the structural integrity (strength and fatigue) of each airplane system throughout its required service life. These efforts, therefore, require continual reexamination during the existence of the airplane system.

2.1.1 Design Criteria

2.1.1.1 Discussion

The design criteria efforts are directed toward specifying the detailed requirements necessary for the structural design of the airplane system. These requirements are intended to ensure adequate strength and service life for the airplane system in the performance of its mission.

The specific design criteria given to the contractor as existing military specifications (e.g., MIL-A-8860 series) or equivalent existing Government air vehicle design publications (e.g., HIAD/Design Handbooks) are altered and revised by appropriate system procurement specifications, contractual agreements, and pertinent state-of-the-art advances. From these, the contractor prepares the formal structural design criteria for the particular airplane system.

Once the design criteria are established and the vehicle becomes a physical entity, certain steps are required to assure the Air Force that it is receiving a vehicle which meets these criteria. These steps are covered in the other phases of the ASIP described in subsequent paragraphs.

2.1.1.2 Requirements

The detailed requirements for specific design criteria are contained in Specifications MIL-A-8860(ASG), MIL-A-8861(ASG), MIL-A-8862, MIL-A-8863(ASG), MIL-A-8865(ASG), MIL-A-8866(ASG), MIL-A-8869(ASG), and MIL-A-8870(ASG).

2.1.2 Planned Operational Usage

2.1.2.1 Discussion

Planned operational usage starts with the concept of the airplane system. Maximum effort must be exerted during the development of the airplane system concept to relate the system to all possible usages as envisioned by advanced planning agencies (Hq USAF and the Using Commands). This is required in order to give early consideration to the loads and conditions of use resulting from flight during selected missions, landing impact, and ground operations. Data subsequently obtained during the actual operational usage phase will verify or provide a basis for revising the initial usage inputs.

The objective is to obtain information for use with statistical data previously obtained from flight maneuvers, turbulence, and ground loading conditions encountered in operational use of similar aircraft to provide a difinitive basis for deriving rational structural design requirements, including fatigue loading spectra. Such data requirements are discussed in the following paragraphs.

2.1.2.1.1 Mission Profile

The mission profile of an airplane system includes the following key data: mission type; takeoffs and landings; stores released; mission phases and related information such as weight, altitude, airspeed, time, configuration; and other pertinent characteristics of the flights.

Using Commands are continuously consulted for data on planned and existing flight mission profiles. Contractors performing a fatigue analysis will be provided the various mission and usage information for their airplane.

2.1.2.1.2 Ground Profiles

The ground profile of an airplane system includes such following key items in terms of time and number of occurrences: taxi speed and durations, braking and turns, engine runs, towing, runway and taxiway roughness characteristics, and takeoff aborts.

The data will normally be estimated during the design phase using knowledge acquired from observation of previous airplanes having similar operational usage. Following delivery of the airplane system to the Using Command, a survey of the ground operations must be made to define a more realistic ground load environment for use in the service-life analysis. This should include statistics on accumulated engine time on the ground under various engine operating conditions for confirming or modifying estimates made in sonic analyses and tests.

2.1.2.2 Requirements

The detailed requirements for deriving fatigue loading spectra are contained in Specification MIL-A-8866(ASG).

2.1.3 Improved Structural Design Information

2.1.3.1 Discussion

One of the objectives of the structural integrity program is to develop and incorporate improved structural criteria and methods of design, evaluation, and substantiation of airplane systems. These efforts include the development of improved predictions of maneuver, gust, and ground loads environment, and are accomplished by exploiting for general application the data generated by structural integrity efforts on individual systems program.

2.1.3.2 Requirements

For each airplane system, the data gathered during the Service Loads Recording Program will be processed by the Air Force and presented in a

format suitable for design criteria studies. The detailed requirements for the data format will be subject to agreement between the Air Force and the contractor.

2.2 INITIAL DESIGN ANALYSES (PHASE II)

The initial design analysis consists of determining: the load and temperature environment, the stress resulting from these loads and temperatures, the sonic environment, flutter and divergence characteristics, and the service-life estimate based upon the planned operational usage, design stresses, and design development and pre-production verification tests.

2.2.1 Loads Analysis

2.2.1.1 Discussion

The loads analysis consists of determining the magnitude and distributions of the external loads which the airplane is likely to encounter in performing its mission within the specified design limits. The critical loads used in the structural design and testing of the airplane are established in the loads analysis.

This analysis will consist of the determination of aerodynamic loads, ground loads, inertia loads, and fatigue-load spectra. When applicable, it will include the effects of temperature, aeroelasticity, and dynamic response of the aircraft. Significant refinements in the definitions of the structural deformation and aerodynamic characteristics determined during fabrication or testing of the airplanes are incorporated in the loads analysis.

2.2.1.2 Requirements

Detailed requirements for the loads analysis are contained in Specification MIL-A-8868(ASG).

2.2.2 Stress Analysis

2.2.2.1 Discussion

The stress analysis consists of the analytical determination of the stress and margins of safety resulting from the external loads and temperatures imposed on the airframe. The analytical ability of the airplane structure to support the critical loads and to meet the specified strength requirements must be established.

Internal loads distributions are developed from the external loads analysis. Analytical stress analysis is then used to size structural components and members. Stress levels are established for the structural members of the airframe and margins of safety are calculated for each member. The minimum margins of safety are listed as part of the stress analysis report. Stress levels of each of the airplane members are used in the fatigue analysis described in paragraph 2.2.3 below.

Since the margin of safety is a comparison of the member strength available and the member strength utilized, it is an input to establishing the growth potential (areas of high margins of safety) of the structure. Areas of low margins of safety are useful in determining critical structural components for preproduction tests and for the determination of the critical loading conditions that should be used in the static tests. Upon completion of the static tests, the stress analysis is modified where necessary to reflect stress levels and margins of safety that correlate with the static test results.

The stress analysis is also used as a basis for calculating the strength of structural changes throughout the life of the airplane. It is also used to determine the adequacy of the structure for new loading conditions that result from increased performance or new mission requirements. The stress analysis is revised to reflect any major changes to the structure or to the loading conditions applied to the structure.

2.2.2.2 Requirements

Detailed description of the extent of the analysis and subsequent stress analysis report is contained in Specification MIL-A-8868(ASG).

2.2.3 Fatigue Analysis

2.2.3.1 Discussion

The fatigue analysis consists of the initial analytical determination of the estimated service life of the airframe resulting from the application of repeated loads and thermal conditions. The objective is to establish the ability of the airframe to sustain these loading conditions for the required service life.

A fatigue analysis is performed by the contractor for each new airplane design and for each subsequent series where there is a significant change in the structural configuration or loads. The analysis will indicate those structural changes necessary to provide the required service life as specified in the procurement specification and as stipulated in paragraph 2.3.1.2. The scatter factors specified in paragraph 2.3.1.2 are minimums. The designer should be guided by the state-of-the-art and may wish to choose a scatter factor greater than that specified to ensure the capability to demonstrate the required service-life values.

The fatigue-load spectra (paragraph 2.2.1) used shall be developed by the contractor based on planned operational usage, the number and type of missions to be flown as determined by the Using Command and the procuring activity, and pertinent statistical environmental data collected on gusts, maneuvers, landing, and taxi obtained by the various Government agencies. Effects of the dynamic (rigid and elastic) responses of the airplane on the amplitude and frequency of load must be considered when applying the environmental spectra given in Specification MIL-A-8866(ASG) or specified by the procuring activity. The load spectra are submitted to the procuring activity for review early in the design stage (prior to first production article roll-out or as specified in the Contract Data Requirements List).

The initial fatigue analysis will identify the major structural modifications to the initial design that are necessary to meet the design service-life requirements and to provide preliminary test load spectra to be used in vehicle and component tests. The structural modifications identified by the initial fatigue analysis are incorporated into the static test and cyclic test article for experimental evaluation.

Review of the initial fatigue analysis by the procuring activity should then precede the start of static tests for those airplanes which are in the design stage or the cyclic fatigue tests for those airplanes that have completed the static test phase.

The final analysis is similar to the initial analysis except that all experimental data obtained from cyclic tests and flight tests are used to refine the life estimate of the airplane. The final analysis is identified as the Service-Life Analysis and is discussed in paragraph 2.4.2.

2.2.3.2 Requirements

Detailed requirements for the fatigue analysis are contained in Specification MIL-A-8868(ASG).

2.2.4 Flutter Analysis

2.2.4.1 Discussion

A flutter and divergence analysis is performed to analytically determine the ability of the airplane structure to meet the specified flutter and divergence safety margins.

Airplane flutter and divergence characteristics resulting from the interaction of the aerodynamic, inertia, and elastic characteristics of the components involved are determined analytically in the flutter and divergence analysis. If significant differences in the aerodynamic , inertia, or elastic characteristics result during testing of the airplane or its components, the flutter and divergence analysis is revised accordingly.

2.2.4.2 Requirements

The detailed requirements for the flutter and divergence analysis are contained in Specification MIL-A-8870(ASG).

2.2.5 Sonic Loads

2.2.5.1 Discussion

The ability of a flight vehicle structure to resist sonic fatigue caused by stress produced by alternating forces having frequencies near structural resonance must be investigated and established. Such forces include power plant noise, pseudo-noise in turbulent and separated airflow, and localized vibratory forces. Sonic fatigue failures can constitute an appreciable maintenance burden and may affect safety of flight.

The objective of this program is to obtain for present and future flight vehicles an airframe subsystem embodying designs which will preclude catastrophic failure due to sonic fatigue cracks, which can be readily inspected and repaired before failures occur affecting the safety and reliability of flight, and which exhibit low incidence of sonic damage consistent with a reasonable mainburden. A further objective is to recommend actions which will prevent adverse effects of sonic fatigue of airplanes.

Sonic loads are expressed in terms of external noise levels which impinge on the vehicle structure. By considering the pressure loads and exposure times from all noise sources at each operational condition, the sonic fatigue design loads can be established within reasonable limits for all areas of the airplane.

The incorporation of the estimated sonic loading into a structural design primarily involves application of fatigue principles to obtain damage-tolerant construction. Where noise levels on the external surface of the structure exceed 140 db, the sonic fatigue resistance of light, secondary components should be evaluated. As noise levels are increased the analysis is extended to increasingly heavier components to ensure that all susceptible structures have been considered.

The structural designer must consider materials, dimensions, spacing, stress risers, stiffness, and construction details which may affect the fatigue life; he must also incorporate damage-tolerant design, where required. A typical approach to sonic fatigue design is given in ASD-TDR-62-820, entitled "Structural Design for Acoustic Fatigue," and AFFDL-TR-67-156, entitled "Refinement of Sonic Fatigue Structural Design Criteria."

The status of the sonic fatigue analysis necessitates that considerable component or element testing be accomplished as early as possible in conjunction with the design fatigue analysis. Two types of component testing are generally employed: (1) quantitative evaluation of fatigue life or components by properly orienting the structure in an actual or simulated noise field and (2) qualitative evaluation of relative improvements in fatigue life when the item is exposed in a horn or siren test facility.

2.2.5.2 Requirements

Detailed requirements for the sonic fatigue analysis are contained in Specification MIL-A-8870(ASG).

2.2.6 Design Development and Pre-Production Verification Tests

2.2.6.1 Discussion

Design development and pre-production verification tests consist of those tests of materials, structural elements, and structural components performed during the design phase. These tests are necessary to establish structural design concepts together with strength and fatigue properties in order to provide a realistic basis for the design analysis and the major structural ground tests.

2.2.6.1.1 Design Development Tests

The design development tests are conducted to establish basic design concepts and configurations such as choice of materials, panel sizes, splices, fittings, etc. These tests are conducted early in the development cycle, and

are the most basic type of structural tests. Design development tests are categorized as follows:

1. Element Tests
   a. Materials Selection
   b. Process Evaluation
   c. Fastener Evaluation
   d. Manufacturing Methods Evaluation
2. Structural Configuration Development Tests
   a. Splices and Joints
   b. Panels (Basic Sections and Sections With Cutouts)
   c. Fittings
   d. Assemblies

2.2.6.1.2 Pre-Production Verification Tests

Pre-production verification tests are conducted to provide necessary design information whenever analytical methods are inadequate to achieve a high degree of confidence in the strength and fatigue properties of the design. These tests of assemblies and components are the beginning of the overall verification test programs; they are selected from among the critical areas, and they use the earliest available production-type parts, including forgings. However, prudent use of substitute parts for forgings may be necessary to ensure early test completion. These pre-production verification tests are separate tests from the major structural ground tests which are later conducted during the testing phase. To provide timely information, these tests must precede the full-scale tests by a sizable time period (as much as 12 to 18 months). Considerable lead time is required to build, set up, or reconfigure a particular critical area of the static test article. These tests must be scheduled (particularly in highly concurrent programs) to provide the information before heavy commitments are made to substantial quantities of hardware; and, in any case, the results of these tests must be available prior to the major structural ground tests. The scheduling and scope of these tests should be such as not to delay the major structural ground tests. Pre-production verification tests are categorized as follows:

1. Splices and Joints

2. Panels
3. Fittings
4. Assemblies of 1., 2., and 3. Above
5. Full-Scale Components Such as Wing Carry-Thru, Horizontal Tail Support, Wing Pivots, Landing Gear and Support, Etc.

2.2.6.1.2.1 Component Test Scatter Factors

Due to an inability to accurately simulate the actual internal load distributions in component test specimens, it is necessary that the static and fatigue pre-production verification tests incorporate additional factors above the 1.5 strength margin of safety and the 4.0 fatigue factor of safety. Inclusion of these additional factors in the component tests will ensure applicability of the test results to the structural integrity of the full-scale structure. Specific values of component test scatter factors will be as agreed to by the contractor and the procuring activity.

2.2.6.2 Requirements

During the design phase, the contractor will prepare a plan for the Design Development and Pre-Production Verification Test Program, and this plan will be reviewed with the procuring activity. This plan will provide the procuring activity with the information necessary to evaluate the program adequacy, to offer advice and, if necessary, direction. The plan will consist of such information as rationale for selection of tests and the scope of tests, description of procedures, test loads, and test factors, and analyses directed at establishing cost and schedule tradeoffs used in developing the program. Detailed requirements are contained in Specifications MIL-A-8867(ASG) and MIL-A-8868(ASG).

2.3 TESTING (PHASE III)

Since the initial design analyses are based on estimated loads and rely heavily on past experience, the structural integrity is uncertain at this stage. The objective of the testing phase is to establish through a series of ground and flight tests an empirical basis for substantiation of the structural integrity of the airplane.

2.3.1 Ground Tests

2.3.1.1 Static Tests

2.3.1.1.1 Discussion

The static test program consists of a planned series of tests, each conducted to 100% of ultimate load on an instrumented airframe. These tests simulate the loads resulting from all critical flight and ground handling conditions. Thermal environment effects will be simulated along with load application on airframes where operational environments impose significant thermal effects.

The objectives of the static test program are: to ensure that the basic design is structurally adequate for the required design ultimate loads, to determine the degree of compliance with prescribed structural design criteria, to determine the degree of growth potential available in the airplane structure, and to alleviate and prevent (where possible) future structural maintenance difficulties.

The static strength-test structure will be a complete airframe assembly and will be the first airframe constructed unless otherwise agreed to by the procuring activity. Upon agreement by the procuring activity, individual components (such as wing, fuselage, empennage, etc.) may be tested separately if sufficient overlap of attaching structure is used to ensure proper load interactions at the structural interface. At least one airframe of each airplane series will be static tested in accordance with MIL-A-8867(ASG) to ultimate loads for all critical conditions. These critical conditions, defined by the contractor prior to the start of the test program, will have been approved by the Air Force. Intentional failing-load tests conducted at the completion of the ultimate-load test program will normally consist of one test for each major component (wing, fuselage, and tail surfaces). In instances where specific growth requirequirements are to be investigated, the failing-load test program will be negotiated in detail with the procuring activity.

The static test together with the combined flight load survey and structural integrity flight demonstration will be used to empirically verify the structural

integrity of the airplane for the design flight envelope. The static test program should be scheduled so that no delays will be incurred in obtaining structural release for flight test to the 100% limit-load flight conditions.

2.3.1.1.2 Requirements

Detailed requirements for static tests are contained in Specification MIL-A-8867(ASG).

2.3.1.2 Fatigue Tests

2.3.1.2.1 Discussion

The fatigue test of the airframe consists of repeated applications of the spectra of cyclic loads simulating actual flight vehicle usage (either predicted or measured) to the complete airframe or to selected separate critical structural components. These tests are conducted to determine probable locations of fatigue damage and to establish those structural modifications required to maintain structural integrity throughout the operational service life. Thermal environments are simulated during the fatigue tests on those airplanes for which elevated temperatures impose significant effects.

The objectives of this program are to: locate any test-detectable fatigue-critical areas of the airframe, provide information early enough in the history of the airplane system to permit essential improvement in the fatigue capability of the aircraft at relatively little increase in cost, develop inspection and maintenance procedures that reduce or eliminate unscheduled structural maintenance problems due to fatigue, provide a ready reference gage of possible damage by comparison of test input with service usage, and provide full-scale test data to establish the predicted service life of the flight vehicle structure.

The verification of the service life predicted by the fatigue analysis will require two full-scale cyclic tests (Figure 2). The test article is to be a complete basic airframe with no previous flight or test history and shall include all necessary alighting gear components. Individual components may be tested separately if it is more expeditious or otherwise feasible, provided a sufficient number of major components is used to ensure complete test coverage.

The first test article will be an early but reasonably representative airframe and will be fatigue tested as early in the program as practical. The test spectrum for the first test article will be based on the design life and usage, the MIL-A-8866(ASG) load environment, and other load data supplied by the procuring activity. Where technically feasible, this test will be accelerated in order to minimize production redesign and retrofit effort, and to provide early short-term protection. To this end, the following program features which affect scheduling will be given consideration: (1) expeditious formulation of the test load spectrum as derived from the design criteria and analysis (to be delivered to the procuring activity prior to first production article roll-out or as specified in the Contract Data Requirements List), (2) Concerted effort toward achieving a shortened test duration by means of rational spectrum compression and rapid load application, (3) expeditious repair of the test article to minimize test downtime in the event of failures, and (4) earliest possible availability of a production airframe and/or major pre-production structural assemblies. The test equivalent damage will precede the fleet by at least a scatter factor of four based on an average usage. It is also desirable that the test remain ahead of the highest usage airplane by a factor of four.

The second fatigue test airframe will be identical to the final production configuration and will incorporate all structural changes resulting from the static test program and the initial fatigue test program. This second test is to establish the fatigue life of the most representative service configurations and should not be conducted until after completion of the first fatigue test program and until a representative load spectrum, utilizing service loads data, is developed (Figure 2 and paragraph 2. 5. 1. 1). Since airplanes can have major changes in usage and gross life extensions are often required, it is advisable to continue the fatigue test until an unreparable, catastrophic failure occurs or until fixes become economically unfeasible. It is also desirable to conduct residual strength tests upon completion of the safe-life tests.

The test spectrum as derived from the load spectrum will simulate total mission profiles including gust, maneuver, landing, and appropriate ground handling operations with a minimum of five load levels for each segment. The test spectrum shall be applied on a flight-by-flight basis. Of particular

importance in determining true fatigue life is the inclusion of the ground-air-ground cycle with its associated stress reversals. The use of the alternate block programming method may be employed, subject to specific approval of the procuring activity. Each block will not exceed 5% of one lifetime. It should be recognized that a block-type spectrum implies unrealistic spacing of the ground-air-ground cycle with the attendant possibility of nonconservative test results. The test load simulation must reasonably duplicate the intended shear, moment, and torsion throughout the test component involved. The test spectrum should reflect the same distribution of damage versus stress level as the spectrum used in the fatigue analysis. Those stress levels causing the largest percent of damage to the operational aircraft should be included in the test spectrum in the proper proportion. Excessive substitution of high stress levels is not acceptable. Based on the test results, an Inspection Report is prepared.

Adequate instrumentation and inspection will be maintained to ensure, within practical limits, that when and if fatigue cracks occur they may be detected as soon after their inception as possible. Crack detection and stress instrumentation are subject to approval by the procuring activity. Special attention must be paid to those areas shown critical by fatigue analysis, and to areas that do not lend themselves to accurate stress analysis or ease of inspection.

The full-scale fatigue test program will demonstrate a duration of at least four times the service-life requirements when the test spectrum as specified in the procurement specification represents an average spectrum. Increases in this factor may be required as appropriate under agreement between the contractor and the procuring activity when indicated by a rational probability analysis of test data and load spectra. Time periods for fleet inspection and retrofit procedures are based upon the test results, including the scatter factor.

2.3.1.2.2 Requirements

Detailed requirements for fatigue tests are contained in Specification MIL-A-8867(ASG).

2.3.1.3 Flutter Tests

2.3.1.3.1 Discussion

The flutter tests consist of wind-tunnel flutter model tests, wind-tunnel aerodynamic model tests, ground vibration tests, influence coefficient and structural rigidity tests, thermoelastic tests, limit load rigidity tests, and control-surface free-play and rigidity tests.

Wind-tunnel aerodynamic model tests may be required for experimental determination of the nonsteady aerodynamic forces acting on the surface of the airplane. The objective is to improve the aerodynamic data which are used in the theoretical flutter analysis. If significant discrepancies exist between the experimental and the theoretical aerodynamic forces, the experimental results will be used in the final flutter analysis.

The ground vibration tests consist of the experimental determination of the natural frequencies, mode shapes, and structural damping of the airplane or its components. The objective is to verify mass and stiffness characteristics which are used in the theoretical flutter analysis. If significant discrepancies exist between the experimental and theoretical vibration modes, the experimental modes will be used in the final flutter analysis.

The influence coefficient and structural rigidity tests, thermo-elastic tests, limit-load rigidity tests, and control-surface free-play and rigidity tests consist of the experimental determination of the structural elastic properties of the aircraft and its components. The objective of these tests is to verify supporting data used in flutter analyses and flutter model design.

2.3.1.3.2 Requirements

The detailed requirements for the flutter tests are contained in Specification MIL-A-8870(ASG).

2.3.1.4 Sonic Tests

2.3.1.4.1 Discussion

The sonic tests consist of a sound pressure survey to define the external noise levels which impinge on the airplane and the associated responses and stresses in the structure during service-type missions, including ground operation of the airplane power plants. Testing to confirm the structural integrity for the design loads used in the sonic analysis is accomplished in several phases starting with elements and components in test cells and concluding with final tests on the flight vehicle.

A proof/demonstration test is the final step in the development cycle. It is normally a test of a full-scale airplane. However, use of major portions of the airplane in ground test stands may be acceptable. The requirement for this test program results from inadequacies in the methods of sonic fatigue analysis and also from compromises in the number and simulation of component testing. The proof/demonstration for sonic fatigue reveals the design details and areas of the structure which may have inadequate service life in the final vehicle. It also serves as a basis for developing inspection and repair techniques for the Using Commands. The proof/demonstration has been accomplished in the past by operating the power plant on the ground under the most severe condition of noise impingement on the structure for a sufficient time to indicate reasonable structural service life. For some airplanes, special problems may arise and require specialized approaches.

2.3.1.4.2 Requirements

Detailed requirements for sonic tests are contained in Specification MIL-A-8870(ASG).

2.3.2 Structural Flight Tests

2.3.2.1 Flight and Ground Loads Survey

2.3.2.1.1 Discussion

The flight and ground loads survey program consists of operating an instrumented airplane within and to the extremes of its structural design envelope to measure the resulting loads for verifying the analytical loads and their distributions. Load measurements (shears, bending moments, torsions) are made by the strain gage and/or pressure survey methods, as specified by the procuring activity.

The objectives of a loads survey are as follows: determination and evaluation of loading conditions which produce the critical structural load and temperature distribution, verification of the analytical structural loads and temperatures used to design the airplane structure, determination and definition of suspected new critical loading conditions indicated by previously conducted investigations, and structural integrity demonstration of the airplane for the critical structural flight and ground conditions within the design envelope.

The airplane(s) to be tested will be designated by the procuring agency. Unless otherwise specified, the second airplane produced of each model will be used to perform a combined flight and ground loads survey, and structural integrity demonstration. An additional airplane, sufficiently late in the production program to ensure obtaining the final configuration, will also be designated for structural flight test and will be instrumented as specified by the procuring activity. This airplane will serve as a standby for the initial test airplane in the event that it becomes impractical or impossible (because of modifications or other reasons) to use the initial airplane for final tests.

2.3.2.1.2 Requirements

Detailed requirements for the flight and ground loads survey are contained in Specification MIL-A-8871(USAF).

2.3.2.2 Dynamic Response Tests

2.3.2.2.1 Discussion

The dynamic response tests are accomplished by measuring the structural loads and inputs while flying the airplane through atmospheric turbulence and during taxi, towing, and landing conditions. The objectives are to obtain flight investigation and evaluation of the elastic response characteristics of the structure to these dynamic load inputs for use in substantiating or correcting the analytical loads analysis, fatigue analysis, and for interpreting the operational loads data.

These tests will consist of performing a gust response survey; landing and taxi tests as outlined below; and of measuring the dynamic loads, gust velocities,

and test condition parameters as appropriate for each type of test. Unless otherwise specified, the dynamic response tests will be performed on the flight loads airplane at the conclusion of the flight loads survey program. In the event that these tests can be phased into the program without delaying the flight loads survey tests, this should be accomplished subject to the approval of the procuring activity.

The gust loads survey investigation consists of flights through continuous turbulence with the airplane loadings, configurations, altitudes, and speeds that are representative of service operation. For those airplanes capable of in-flight refueling, additional tests will be conducted during simulated in-flight refueling with the airplane loading, configurations, altitudes, and speeds that are representative of such operation.

The dynamic landing-loads tests will consist of a sufficient number of landings to adequately define the landing gear loads and transfer functions between gear loads and the wing and fuselage structure. The taxi loads tests are intended to establish the effects of various taxi and towing conditions as well as to establish the effects of runway roughness on the dynamic elastic loads of the airplane landing gear and structure at representative loadings, configurations, and speeds.

2.3.2.2.2 Requirements

Detailed requirements for dynamic response tests are contained in Specification MIL-A-8871(USAF).

2.3.2.3 Thermal Flight Tests

2.3.2.3.1 Discussion

Thermal flight tests are conducted as part of the flight loads survey during which the airplane encounters significant temperature conditions on the airframe. The objective is to obtain flight determination of the temperatures of various structural components for verification of the analytical temperatures used in the design of the airframe.

2.3.2.3.2 Requirements

These flight tests are conducted and reported as a part of the Flight and Ground Loads Survey (paragraph 2.3.2.1). The contractor must confer with the procuring activity to establish the extent of both the instrumentation and the tests required for a particular airplane. Detailed requirements for thermal flight tests are contained in Specification MIL-A-8871(USAF).

2.3.2.4 Flight Flutter Tests

2.3.2.4.1 Discussion

Flight Flutter tests of representative and critical configurations using an instrumented airplane and appropriate means of excitation are conducted at the critical altitudes from minimum cruising speed up to the limit speed.

The tests are to verify the absence of flutter and the presence of safe flutter margins. Adequate damping of flight flutter modes of motion and damping trends with increasing airspeed are to be determined.

Flight flutter testing alone is not used to substantiate freedom from flutter. It is only used as a final check to substantiate freedom from flutter as indicated by the flutter analysis and wind-tunnel flutter model tests.

2.3.2.4.2 Requirements

The detailed requirements for the flight flutter tests are contained in Specification MIL-A-8870(ASG).

2.4 FINAL STRUCTURAL INTEGRITY ANALYSIS (PHASE IV)

Once the design analyses and testing are accomplished, all of the results must be collected to summarize the strength and service life of the airframe. The objective is to establish the structural integrity of the airplane for all specified design conditions, or to establish the restrictions required to

maintain structural integrity. The structural flight limits and restrictions thus defined and approved are published in the -1 Handbook for pilot's use.

2.4.1 Strength Summary and Operating Restrictions Analysis

2.4.1.1 Discussion

The Strength Summary and Operating Restrictions Analysis summarizes the strength of the airframe and recommends any necessary restrictions for operational use of the airplane based upon the results of ground and flight tests. A Strength Summary and Operating Restrictions Analysis is required for each airplane model as per Specification MIL-A-8868(ASG) and is described further in WADC Technical Report 57-162 DDC document Nr AD-118-326. This analysis and the subsequent report must be revised as changes are made to the airplane structure.

2.4.1.2 Requirements

Detailed requirements for the Strength Summary and Operating Restrictions Analysis are contained in Specification MIL-A-8868(ASG).

2.4.2 Service-Life Analysis

2.4.2.1 Discussion

The Service-Life Analysis consists of integrating the results of the ground tests, flight tests, and operational loads data into the initial fatigue analysis (paragraph 2.2.3). It establishes the service life of the fleet for its defined operational usage or revisions thereto in the event of significant changes in the operation of the airplane.

The Service-Life Analysis shall include life calculations of all primary and basic structure. As mentioned in paragraphs 1.5.1 and 2.2.3, the loads spectra, fatigue analysis, and test spectra developed in support of the first fatigue test are based on design information and must be maintained and revised on a continuing basis. The various revisions are shown in Figure 2. The

service-life analysis is prepared from the fatigue analyses (paragraph 2.2.3) and incorporates all significant information from the static test, first fatigue test, structural flight test, and actual operational usage programs. This analysis enables preparation of an updated test spectra for the second fatigue test. After completion of the second fatigue test, the service-life analysis is again revised to incorporate the latest damage information from this late test. Finally, the service-life analysis must be revised whenever information obtained from the actual operational usage phase indicates a change in the loads environment or aircraft utilization.

2.4.2.2 Requirements

Detailed requirements for the Service-Life Analysis are contained in Specification MIL-A-8868(ASG).

2.4.3 Parametric Fatigue Analysis

2.4.3.1 Discussion

The Parametric Fatigue Analysis provides a basis for evaluating the effects of variations in normal operational usage on the service life of the airframe as well as a basis for maintaining a continuous record of the fatigue damage accumulated on individual airplanes (paragraph 2.5.2).

The Parametric Fatigue Analysis will contain damage per unit time per segment of mission, or per mission as a function of the significant mission parameters. The analysis will be programmed for a large-scale digital computer. It must be capable of calculating fatigue damage from the information provided in the airplane structural flight record such as mission, configuration, gross weight, speed, altitude, time, etc. It must also be flexible enough to allow adequate revision when the life history recorded data indicate a change in the statistical model for any significant loads parameter.

2.4.3.2 Requirements

Detailed requirements for the Parametric Fatigue Analysis are contained in Specification MIL-A-8868(ASG).

2.5 ACTUAL OPERATIONAL USAGE (PHASE V)

The accuracy of service-life predictions is dependent on the accuracy of the loads spectra and actual airplane utilization used in the fatigue tests and in the analyses. To establish or refine the loads spectrum of each of the airplane systems in the ASIP, it is required that information relating to the actual loads and utilization encountered by these airplanes be measured. The actual operational usage effort must be conducted concurrently with airplane production (commencing not later than acceptance of the first operational airplane) so that loads information can be obtained on a timely basis, and so that information relating to the complete usage history will be available on each airplane. These measurements will be made by the use of Operational Loads Recording Systems and individual Airplane Service-Life Monitoring Systems as specified by the Air Force. Data processing is accomplished by the Air Force.

2.5.1 Operational Loads Recording Program

The Operational Loads Recording Program gathers information of structural loads encountered by operational airplanes in order to establish or reevaluate the fatigue spectra, service-life expectancy, inspection schedules, modification and maintenance schedules, new mission techniques, and operational limitations, as well as for providing data for the development of improved structural design criteria for other future airplanes. These measurements will be made through the installation of operational loads recording systems on a percentage of the fleet.

2.5.1.1 Discussion

2.5.1.1.1 Service Loads Recording Program

The objective of the Service Loads Recording Program is to provide loads spectra of operational airborne and ground loading experience on all the major structural components of the airplane. These data are used for the establishment of the loads spectrum for the second full-scale fatigue cyclic test and for reevaluating and updating the basic parametric calculations. The choice of loads parameters is totally dependent upon what is needed to describe the loads

spectra on the major structural components of the airplane. The information to be recorded will consist of airplane operational parameters such as airspeed, altitude, linear accelerations, angular velocities, etc. Supplementary information such as gross weight, fuel weight, mission, etc. may be required in conjunction with the recorded data.

It should be noted that a sample of operational loading information can be acquired early in the life of the airplane by instrumenting the airplanes involved in the Lead-The-Force Program presently being conducted on certain USAF systems. This would provide timely information for the establishment of loads spectra for the second fatigue test. However, it should be recognized that the LTF concept is not an integral part of the ASIP. LTF is not used as a basis for predicting impending structural fatigue failures or structural "health" for the fleet. The point to be made is that when LTF Programs are initiated to provide overall system surveillance, then operational loading information can be obtained in an accelerated manner by instrumenting LTF airplanes.

2.5.1.1.2 Life History Recording Program

The life History Recording Program is basically a continuation of the Service Loads Recording Program. The objective is to supply sufficient information at any point in the life of the airplane to determine if major structural components which contain fatigue-critical areas are encountering a loading environment (maneuver, gust, ground) different from that established in the Service Loads Recording Program. It is intended that the recorders used for the Service Loads Recording Program be retained in the airplanes to accomplish the Life History Recording Program. However, because of the identification of the fatigue-critical areas by the cyclic test, the number of parameters to be measured may be reduced. If a significant change in the operational loads environment occurs, a new loading spectrum for the major structural components must be determined. This would entail further measurement of the same parameters recorded in the Service Loads Recording Program. Any such changes in the loads environment will also be incorporated into the Parametric Fatigue Analysis to reflect the new damage rates.

2.5.1.2 Requirements

The Air Force will procure and install magnetic tape recorders on a percentage of each airplane system. The data gathered during the Operational Loads Recording Program will be processed by the Air Force and presented in a format suitable for preparation of the loads spectra. The number of recorders, selection of parameters, and format of the reduced data will be subject to agreement between the Air Force and the contractor. The detailed requirements for the reporting of the data obtained from the Operational Loads Recording Program are contained in Specification MIL-A-8868(ASG).

2.5.2 Individual Airplane Service-Life Monitoring Program

2.5.2.1 Discussion

The Individual Airplane Service-Life Monitoring Program monitors damage at the fatigue-critical points for each aircraft to establish safe operational life, inspection schedules, repair schedules, replacement parts procurement, and life tradeoff versus operational utilization for future planning.

Individual airplanes or groups of airplanes can accumulate fatigue damage at widely varying rates depending on usage. These variations from the fleet average must be assessed to prevent catastrophic failures or requirements for unscheduled maintenance in the fleet. In lieu of instrumenting 100% of the fleet with structural loads recorders, the program is accomplished by collecting a written structural flight record of every flight for each airplane in terms of operational mission parameters (gross weight, altitude, velocity, airplane configuration, special operational procedures, etc.). The necessary parameters to be recorded are established from the Service-Life Analysis and the Parametric Fatigue Analysis.

On certain types of airplanes, consideration should be given to obtaining individual airplane operational usage data by some means additional to a written structural flight record. For example, on fighter airplanes, it may be desirable to assess damage variation based on actual acceleration counts for each airplane rather than on mission parameters alone. The use of exceedance

counter accelerometers, strain-range counters, damage sensors, or similar instruments will be considered.

The information on the records will be processed through the Parametric Fatigue Analysis to determine the accumulation of fatigue damage by tail number. A report will be compiled according to a predetermined schedule and will contain such data as the following: total flight, landings, etc.; total accumulated damage by load source at the most fatigue-critical control points; incremental damage per period; remaining airplane safe operational life, and total fleet utilization (hours, flights, etc.). Data output will be in tabulated form with a running tally for each airplane. In addition, the basic damage rates as a function of mission parameters will be presented in graphical form to facilitate life trade studies.

2.5.2.2 Requirements

The Using Commands will utilize structural flight records on every flight of each airplane to record those mission parameters necessary for monitoring damage accumulation. The type of structural flight record and the mission parameters to be recorded will be subject to agreement between the Using Command, ASD, and the contractor.

Detail requirements for the Individual Airplane Service-Life Monitoring Reports are contained in Specification MIL-A-8868(ASG).

2.6 INSPECTIONS (PHASE VI)

2.6.1 Discussion

One of the goals of the ASIP is to develop techniques and procedures for logistic support in terms of inspection requirements. The extent of structural inspections is established from the Service-Life Analysis, and from unique considerations such as areas of unusual structural design, use of new or exotic materials, discrete crash or battle damage, etc. These inspections provide added assurance of the structural integrity of critical areas identified

through the testing and actual operational usage phases. Where applicable, the areas will be inspected during normally scheduled ACI or IRAN. Inspection requirements which are not compatible with these established programs will require special inspection periods.

2.6.1.1 Analytical Condition Inspection (ACI)

The ACI is defines in AFLCR 66-28 and is a systematic disassembly and inspection of representative airplanes to locate hidden defects, deterioration conditions, corrosion, fatigue, over-stress, etc. The objectives of the ACI are to ensure continued structural integrity of the airplanes, improve system reliability, and establish depot level work requirements and IRAN cycle. Full Advantage will be taken of Nondestructive Inspection (NDI) techniques to aid in detecting defects in inaccessible areas.

2.6.1.2 Inspection and Repair as Necessary (IRAN)

The criteria for IRAN are established in T.0. 00-25-4 and the purpose is self-explanatory. The IRAN cycle for any given weapon system is based on the ACI and maintenance data records. Structural areas which are suspected of exceeding the bounds of the scatter factor will be identified and proper inspection techniques established. Scheduling for the accomplishment of these inspections will take full cognizance of the IRAN schedules. Consistent with the assurance of structural integrity, unique inspections will be scheduled during the IRAN cycle when feasible.

2.6.1.3 Special Inspections

The purpose of these inspections is to inspect the structure which has been identified as a possible critical area when the required inspection intervals are not compatible with normally scheduled inspections. Unexpected early fatigue failures experienced in test or service, adverse production tolerance build-up, inadvertent material production deviations, and state-of-the-art limitations may require that special inspections be conducted. These inspections, when required, will utilize the latest NDI techniques to minimize the variables

introduced by structural disassembly. Operational requirements and impact of downtime must be considered when inspection methods and schedules are developed. The economical and operational impact of special inspections requires that they be minimized by conducting a thorough ASIP.

2.6.2 Requirements

Specific requirements for inspections will vary between individual systems. Based upon the results of the analyses and test, the contractor prepares an inspection report for review and approval by the procuring activity. Detailed requirements for the Structural Fatigue Inspection Report are contained in MIL-A-8868(ASG).

SECTION 3.0

ASIP MASTER PLAN

3.1 DISCUSSION

The Aircraft Structural Integrity Program Master Plan translates the general requirements of Section 2.0 of this document into specific requirements for the particular airplane system. This plan will provide an overall guide to the structural integrity approach for each specific airplane system to ensure that proper program objectives will be obtainable. The plan will be for the entire life span of the airplane from contract definition through operational usage.

In general, the plan will contain the scope of the individual ASIP elements, program deviations or realignments, status (including percent of effort completed), and any program schedule slippages. The discussion will include complete justification for any exceptions to the general requirements. An overall master schedule will be included, and will show phasing and interfaces with other portions of the Category I Test Plan. The plan will also include a detailed ASIP data flow diagram which assigns specific data collection, reduction, dissemination, storage, and analysis responsibilities.

3.2 REQUIREMENTS

The ASIP Master Plan will be prepared and submitted by the contractor during the definition phase of airplane development (Table II). The plan will be updated periodically during the acquisition and operational phases to report progress, to reflect any program changes, and to provide a basis for the annual status reports to Air Force headquarters as required by AFR-80-13.

Detailed requirements for the ASIP Master Plan are contained in Specification MIL-A-8868(ASG).

TABLE II

Relation of ASIP Requirements Phases to AFSCM 375-4 Phases

ASIP REQUIREMENTS PHASES	AFSCM 375-4 PHASES			
	0	I	II	III
ASIP Master Plan		I	U	U
Design Information (Phase I)	I	U	U	
Initial Design Analysis (Phase II)		I	U	U
Testing (Phase III)			I	U
Final Structural Integrity Analysis (Phase IV)			I	U
Actual Operational Usage (Phase V)			I	U
Inspections (Phase VI)			I	U

I - Refers to Initiate

U - Refers to Update

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13. ABSTRACT

This report summarizes requirements for the airplane portion of the Aircraft Structural Integrity Program based upon the results of experience and events since the inception of the program in 1958. It supplements the detailed structural specifications for Air Force airplanes and updates Aeronautical Systems Division Technical Report 66-57, dated January 1968. Applicable military specifications are referenced throughout.

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14. KEY WORDS	LINK A		LINK B		LINK C	
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